Maxillofacial Rehabilitation

Prosthodontic and Surgical Management of Cancer-Related, Acquired, and Congenital Defects of the Head and Neck, *Third Edition*

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Dedication

This textbook represents the culmination of 40 years of patient care, teaching, and research and is dedicated to my father, John Beumer Jr, my mother, Elizabeth Ruth Beumer, and my wife, Janet Lauritsen Beumer, for their continued and devoted support of my work in maxillofacial prosthetics over the span of my professional career.

—John Beumer III

It is with profound gratitude and appreciation that I dedicate this textbook to my parents, Otto and Jean Marunick; to my siblings, John and Kathryn; and to my wife, Robin Edwards Marunick. Their unwavering support in my career development and ongoing encouragement over the years has fostered my dedication in the field of maxillofacial prosthetics. I thank my children, Mark, Piper, and Joel, for their forbearance and understanding during the completion of this project. I also recognize all of my mentors at the various stages of my career.

—Mark T. Marunick

My contribution to this comprehensive textbook must be dedicated to several people. First and foremost, to my wife and partner, Kathleen, the love of my life, for her never-ending support; to our very supportive children, Lisa, Jennifer, and Scott; to my mentors, S. Howard Payne, Ed Mehringer, and Norman Schaaf; and to my parents, Louis and Katherine Esposito, all of whom have been instrumental in making me the person I am. Last but certainly not least, to my good friend John Beumer, who allowed me to affix my name to this book. Clearly, he has been its driving force and without his energy it would never have happened. Thanks, John; you have brought our specialty to new levels with your commitment to patient care, research, education, and again with this outstanding textbook.

—Salvatore J. Esposito

Preface to the Third Edition

Rehabilitation of patients with disabilities of the head and neck secondary to acquired and congenital defects continues to be a challenging endeavor, requiring close interaction between many health care disciplines. Not so long ago, it was difficult to rehabilitate these patients on a consistent basis. Today, however, it is possible to restore the majority of them to near normal form and function, enabling them to lead useful and productive lives. How has this come to happen? What has changed? In the 1980s, two key technical advances—the introduction of osseointegrated implants and free vascularized flaps—were made, but in recent times the most significant changes are the result of improved collaboration between prosthodontic and medical researchers and clinicians. Many challenges remain; for instance, we have yet to find an effective means of minimizing the very significant long-term side effects of chemoradiation therapy. Yet, for the most part, we have made great strides in the last 15 years.

Nevertheless, the pace of change in the rehabilitation of oral and facial defects, given the technical advances made in reconstructive surgery, maxillofacial prosthetics, and dental care of the irradiated patient, has been far too slow. Changes in the quality of care would occur much more rapidly if cancer therapists would employ a truly multidisciplinary approach to clinical care and research. For example, free tissue transfers have been used throughout the world for the last 20 years to restore boney defects of the mandible, but still far too many surgeons fail to understand that it is equally important to restore the bulk and contour of the tongue if the oral functions of speech, mastication, and control of saliva are to be restored. Hence, we appeal to our readers to work with their colleagues toward a multidisciplinary approach to cancer care and to encourage and participate in multidisciplinary research efforts. Surgeons, radiation oncologists, and medical oncologists must be made to appreciate the advantages of making their dental colleagues equal members of the cancer therapy, rehabilitation, and research team. Treatment strategies developed for head and neck cancer patients must always consider the need to maintain or restore oral functions and oral health. No longer should we hear the cliché so often echoed in the past, and even today, in reference to one of our patients: "The cure was worse than the disease."

The prosthodontist is the undisputed expert on oral function and the person most capable of restoring it when it is lost, but to be an effective member of this multidisciplinary effort he or she must not just understand the prosthodontist's role but those of the other team members as well. The prosthodontist must understand the issues important to the cancer surgeon, the reconstructive surgeon, the radiation oncologist, and the medical oncologist in order to make intelligent and practical contributions to the care of these patients. Indeed, all members of the treatment and rehabilitation team must be familiar with the expertise of the other team members so that treatment can be smoothly integrated. And so, in keeping with the multidisciplinary nature of this field, we have attempted to provide insights into the etiologies and procedures for treating defects associated with the maxilla, mandible, and facial structures, and related disabilities, as well as the procedures for rehabilitation.

Readers familiar with the second edition will note that three chapters, "Maxillofacial Trauma," "Cranial Implants," and "Miscellaneous Prostheses," have been deleted, although pertinent portions of these chapters have been incorporated into existing chapters. Two new chapters—"Digital Technology in Maxillofacial Rehabilitation" and "Tissue Engineering of Maxillofacial Tissues"—have been added, reflecting the impact that computer-aided design/computer-assisted manufacturing and molecular biology will have on our discipline. In addition, the psychosocial portion of the book (formerly Chapters 1 and 2) has been completely reconceived and condensed into a single chapter (Chapter 9). We are especially pleased by the efforts made by David A. Rapkin and Neal Garrett for this chapter, which represents a very significant contribution. All chapters devoted to the prosthetic restoration of acquired oral and facial defects have undergone significant revision, reflecting the knowledge and sophistication we have gained over the last few years in the use of osseointegrated implants, free vascularized flaps, and CAD/CAM. A new section devoted to the use of implants in growing children has been added to Chapter 6, "Rehabilitation of Cleft Lip and Palate and Other Craniofacial Anomalies." Chapter 1, "Oral Management of Patients Treated with Radiation Therapy and/or Chemoradiation," has been completely rewritten and reflects the knowledge gained in the last 15 years regarding the dental management of the irradiated patient.

Acknowledgments

We would like to thank our many contributors. At their institutions they have embraced and through their contributions helped us to expand our vision of multidisciplinary care. We would also like to take this opportunity to pay tribute to the contributions made to this discipline and to this text by Professor Thomas A. Curtis. Many of his ideas, treatment philosophies, and words of wisdom remain. He has had a profound influence on the lives and the careers of many colleagues and mentored several who have made major contributions to this book.

The principal editor would like to take this opportunity to personally thank his mentors—Dr Sol Silverman Jr, Professor of Oral Medicine, University of California, San Francisco; Dr Thomas A. Curtis, Professor of Prosthodontics, University of California, San Francisco; and Dr F. J. Kratochvil, Professor of Prosthodontics, UCLA. These individuals are rightly considered giants in their respective disciplines. Their commitment to and enthusiasm for their work and their pursuit of excellence have been inspiring to me and many others. They gave me the basic tools that have permitted me to build bridges across professional barriers and forge the close professional relationships necessary for true progress in this complex and fascinating field.

The authors of Chapter 7, "Digital Technology in Maxillofacial Rehabilitation," wish to dedicate it to Dr Henk Verdonck of the Netherlands. Dr Verdonck was one of the pioneers of the application of digital technologies to maxillofacial prosthetics and made a major contribution to the chapter. His untimely death has deprived our specialty of an immensely creative and innovative professional, and we will miss his contributions to our discipline.

Finally, we would like to thank Brian Lozano, senior artist, UCLA School of Dentistry. He has meticulously redrawn all of the previous illustrations and added several new ones.

Preface to the Second Edition

Rehabilitation of patients with disabilities of the head and neck secondary to acquired and congenital defects is a difficult task, requiring a close interaction among a number of health science disciplines. This book seeks to place the various disciplines in proper perspective in the rehabilitation process. Since the dentist is the primary person involved in many facets of care, much of this book is directed toward the profession of dentistry. However, because of the multidisciplinary nature of this topic, we believe the material will also have relevance for surgeons, radiation therapists, social workers, and other health science professionals.

The disabilities range from minor cosmetic discrepancies to a major functional disability combined with cosmetic disfigurement. The deliverer of therapy must understand posttreatment sequelae and be cognizant of the variations in therapy that significantly improve the process of rehabilitation. In addition to being experts in their respective fields of responsibility, all members of the treatment and rehabilitation team must be familiar with the expertise of the other members of the team so that therapy and rehabilitation may be smoothly integrated. In keeping with the multidisciplinary nature of this topic, we have attempted to give the reader insights into the etiologies and treatment procedures for defects associated with the mandible, maxilla, soft palate, and facial structures, as well as the associated disabilities and the procedures for rehabilitation.

Writing a text which attempts to define a diverse subspecialty, such as maxillofacial prosthetics, is a daunting task. One feels as if a first edition is never really completed. One simply exhausts his or her allotted time and energy, concluding the effort with the hope that a second edition will correct the known limitations. For these reasons, an old adage in literary parlance states that a first edition should never be published. However, a subsequent edition provides another opportunity to define the subject. Readers familiar with the original edition will note that 2 chapters, "Prosthetic Implications of Oral and Maxillofacial Surgery" and "Reconstructive Preprosthetic Surgery," have been deleted, but portions of these chapters survive in new or existing chapters. Two new chapters, "Behavioral and Psychosocial Issues in Head and Neck Cancer" and "Maxillofacial Trauma," have been added, broadening the scope of the text. Moreover, the chapter, "Cleft Lip and Palate," has been completely rewritten, while others (eg, "Acquired Defects of the Mandible" and "Restoration of Facial Defects") have received major revisions, reflecting the changes in care resulting from the use of free vascularized flaps and osseointegrated implants. The remaining chapters have all been revised and updated to include newer techniques, such as the use of osseointegrated dental implants, 3-D image processing and stereolithography, and so on.

We would like to thank all of our many contributors. They helped us to expand our multidisciplinary vision and understand our role in the rehabilitation of our mutual patients. Without them, this book would certainly not have been possible. Also, we would like to acknowledge the contribution of David Firtell, who chose not to participate as a third editor for this edition, but whose words and thoughts remain from past contributions. By the same token, we welcome Mark Marunick as the third editor and contributor.

Writing this book required the efforts of many dedicated individuals, and it is indeed difficult to identify them all. Several persons stand out, however, and the principal editor would like to take this opportunity to thank those individuals whose counsel and aid during his professional development eventually enabled him to undertake this endeavor: Thomas A. Curtis, Sol Silverman, Jr, and F. J. Kratochvil.

We all wish to thank Mickey Stern for the enormous task of typing the final manuscript, Irene Petravicius for her wonderful illustrations, and Walter Livengood for his superb editorial effort.

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Chapter 2

Rehabilitation of Tongue and Mandibular Defects

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The management of malignant tumors associated with the tongue, floor of the mouth, mandible, and adjacent structures represents a difficult challenge for the surgeon, radiation oncologist, and prosthodontist in terms of both control of the primary disease and rehabilitation following treatment. The most common intraoral sites for squamous cell carcinoma (SCC) are the lateral margin of the tongue and the floor of the mouth. Both locations predispose the mandible to tumor invasion, often necessitating its resection in conjunction with large portions of the tongue, the floor of the mouth, and the regional lymphatic system.

Disabilities resulting from such resections may include impaired speech articulation, difficulty in swallowing, problems with mastication, altered mandibular movements, compromised control of salivary secretions, and severe cosmetic disfigurement. In the past 20 years, free tissue transfers and dental implants have resulted in considerable improvement in the form and function of these patients. The impact of free tissue transfers in reconstruction of the tongue and mandible and osseointegrated implants for retaining prostheses has been particularly notable. With these new surgical and prosthodontic methods, more patients with defects of the tongue and mandible can have their appearance and function restored to levels that approach their presurgical condition. These rehabilitative efforts are more complex and require the efforts of a sophisticated, well-trained, multidisciplinary team of oncologic surgeons, maxillofacial prosthodontists, reconstructive surgeons, speech therapists, social workers, and others.

Although available, osseous and soft tissue free flaps and osseointegrated implants for various reasons may not always be indicated or possible. In such instances, rehabilitation efforts will be challenged and functional outcomes are frequently diminished.

Treatment modalities for malignant neoplasms that invade or approximate the mandible or contiguous soft tissues impact the jaw, which can least afford to be compromised. Many vital and life-sustaining functions evolve around the moveable mandible, tongue, and adjacent structures. A partially resected tongue compounds the problem, because it will not function like a normal tongue. A mandible reconstructed with an osseous free flap can demonstrate relatively normal mandibular movements and appearance but altered sensory status may still result in less than optimal function. Radiation therapy also has a significant impact on mandibular structures. The functional movements and occlusal proprioception of a mandible that has lost bony continuity are entirely different from normal mandibular movements and occlusion.

It is unrealistic to discuss functional impairment without reference to the psychic and social factors that affect patients with mandibular resections. Distortions in self-image, inability to communicate, and altered family and vocational roles require the reconstruction of psychic systems to handle these new demands. Those involved in rehabilitation of these patients must be sensitive to the emotional trauma precipitated by cancer and its treatment.

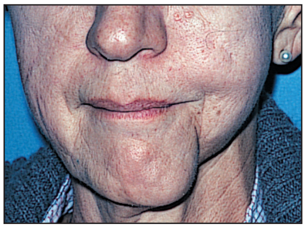

Fig 2-25 Composite resection defect. The intraoral wound was closed primarily.

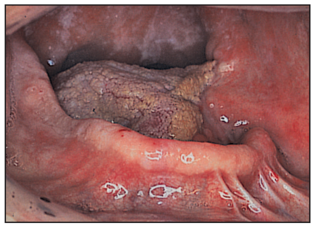

Fig 2-26 Tongue sutured to the buccal mucosa following hemiglossectomy. Tongue mobility is limited, compromising oral function.

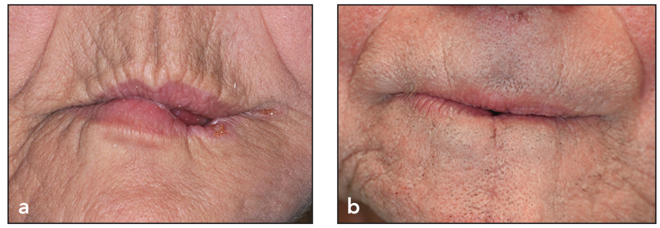

Fig 2-27 *(a)* Appearance following composite resection. The lip is retracted and the corner of the is mouth lowered. *(b)* Scarring and resection of the marginal mandibular nerve may prevent effective lip closure.

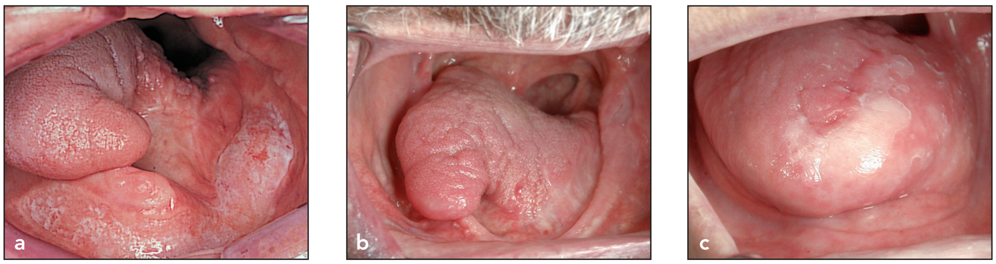

Fig 2-28 Mandibular continuity either maintained or restored after partial glossectomy. *(a)* Hemiglossectomy defect. The mandible has been reconstructed with a free graft. *(b)* Partial glossectomy defect with primary closure. Mandibular continuity is maintained. *(c)* Hemiglossectomy defect restored with a radial forearm flap. Mandibular continuity is maintained. Only the patient in *(c)* will have a chance to use a complete denture successfully for mastication.

Tongue function is dramatically compromised unless the bulk is restored with a flap (Figs 2-28a and 2-28b). Tongue function is less affected if the resected portion is restored with a free flap. Myocutaneous flaps restore lost bulk and prevent the severe mandibular deviation that occurs in patients whose defects are closed primarily. The residual tongue and flap are centered beneath the palatal structures, permitting the reconstructed tongue to articulate speech phonemes more effectively. Myocutaneous flaps, however, become scarred and immobile and thus limit the mobility of the residual tongue, and speech articulation may remain poor (see Fig 2-11).

In contrast, most patients whose tongues are reconstructed with free flaps have the potential of achieving nearly normal speech. The flap restores lost bulk, as does the myocutaneous flap, but it does not become heavily scarred and immobile. Thus, the mobility of the residual tongue is improved dramatically. With speech therapy, the patient learns to manipulate the residual tongue musculature and flap quite effectively, to the point that the quality of speech articulation approaches normal limits in many patients (Fig 2-28c).

Like speech, the degree to which deglutition is adversely affected depends on the extent of surgery and the method of closure. In normal patients the tongue, in concert with the soft palate, directs the bolus posteriorly to the oral pharynx with a synergistic squeezing action. This act is performed with far less efficiency in patients with tongue resections, although eventually most patients learn to swallow quite acceptably. Patients subjected to primary closure experience the most difficulty swallowing because they cannot elevate the tongue sufficiently to propel the food bolus posteriorly. Patients whose tongue bulk is restored with free flaps experience the least difficulty and many are able to swallow in a nearly normal fashion. (The physiology of oral function following resection will be discussed in detail later in the chapter.)

In patients whose wound is closed primarily following surgical resection, if mandibular continuity is not restored, the remaining mandibular segment will retrude and deviate toward the surgical side at the vertical dimension of rest (Fig 2-29). When the mouth is opened, this deviation increases, leading to an angular pathway of opening and closing. It is not uncommon to note 1- to 2-cm deviation laterally and 2- to 4-mm retrusion posterior to the chin point during maximum opening. When the incisal point of the mandible is traced, this diagonal pathway of closure is obvious.[204] During mastication, the entire envelope of motion occurs on the surgical defect side[204] (Fig 2-30). Some patients are unable to effect lateral movements toward the nondefect side and are incapable of making protrusive movements. Patients whose resections are closed with a myocutaneous flap or a free tissue transfer demonstrate much less deviation, regardless of whether or not mandibular continuity is restored.

In patients whose mandibular continuity has not been restored, loss of the proprioceptive sense of occlusion leads to uncoordinated, imprecise movements of the mandible. In addition, the absence of the attachments of the muscles of mastication on the surgical side results in a significant rotation of the mandible on forceful closure. When viewed from the frontal plane, teeth on the surgical side of the mandible move away from the opposing maxillary teeth after initial contact on the nonsurgical side has been established. As the force of closure is increased, the remaining mandible actually rotates through the frontal plane, leading to the term *frontal plane rotation* (Fig 2-31). This factor, with the addition of impaired tongue function, may totally compromise mastication in some patients. Frontal plane rotation is observed in most patients with lateral mandibular discontinuity defects, regardless of whether the site has been closed primarily or with a myocutaneous or a free flap.

If mandibular continuity is not restored, the severity and permanence of mandibular deviation are highly variable and are dependent on a number of complex factors, such as the amount of soft and hard tissue resected, the method of closure, and so forth. Patients whose wounds are closed with a myocutaneous or free

Fig 2-29 Severe deviation of the mandible following composite resection of a lateral floor of the mouth lesion.

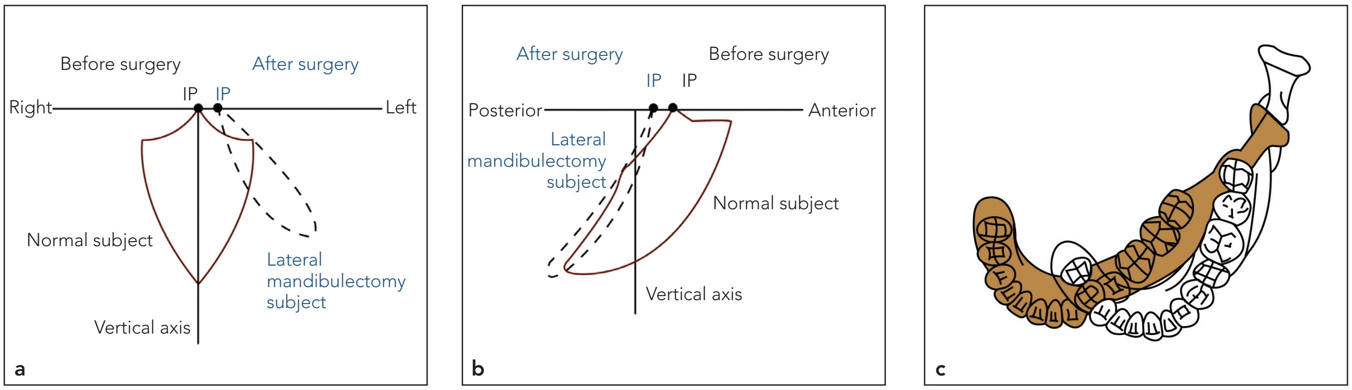

Fig 2-30 *(a)* Envelope of motion as viewed in the *(a)* frontal and *(b)* sagittal planes in a normal patient *(solid lines)* and a patient who has undergone lateral mandibular resection *(broken lines)*. IP–Interocclusal position. *(c)* Position of the remaining mandible in open *(shaded)* and closed *(white)* positions. Note the character of lateral movements toward the resected side. This lateral movement is somewhat reproducible.

Fig 2-31 *(a and b)* Frontal plane rotation. As the force of mandibular closure is increased, the mandible rotates around occlusal contacts on the unresected side, and the remaining teeth on the resected side drop further out of occlusion. *(c)* Occlusal relationship on the unresected side in a patient with a lateral discontinuity defect. Note the difference before *(left)* and after *(right)* surgery.

flap soon attain an acceptable interocclusal relationship, without adjunctive therapy, although some patients whose wounds are closed primarily are never able to achieve an appropriate and stable interocclusal position.

When a usable occlusal relationship is achieved, the mandibular teeth often occlude distal to the presurgical pattern of cuspal interdigitation. On the nonsurgical side, the buccal slopes of the mandibular buccal cusps function with the central fossae of the maxillary teeth because of mandibular rotation in the frontal plane (see Fig 2-31c). Scar contracture, tight wound closure, and muscle imbalances secondary to the primary resection all contribute to mandibular deviation. Mandibular deviation is most severe following primary closure of base of the tongue lesions.

Control of saliva is profoundly affected by most resections of the tongue and mandible. These resections obliterate the lingual and buccal sulci and consequently a means of collecting and channeling secretions posteriorly no longer exists. In addition, the motor and sensory innervation of the lower lip on the resected side is often lost, adversely affecting oral competency and preventing the patient from detecting secretions escaping from the mouth. Impaired sensory innervation and poor tongue control and mobility also contribute to poor control of saliva. Individuals with unimpaired tongue function are capable of identifying escaping secretions and to use the tongue to direct these secretions posteriorly to be swallowed. With compromised tongue function, this manipulation often is impossible.

Drooling is compounded on the defect side by the drooping of the corner of the mouth. Cracking and large fissures develop, and these may become infected with *Candida albicans* (Fig 2-32).

Most patients who submit to lateral resections of the mandible present with varying degrees of trismus following surgery. Trismus is most severe in those patients requiring preoperative or postoperative radiation therapy and is more likely if the patient receives chemoradiation. Early initiation of a well-organized mandibular

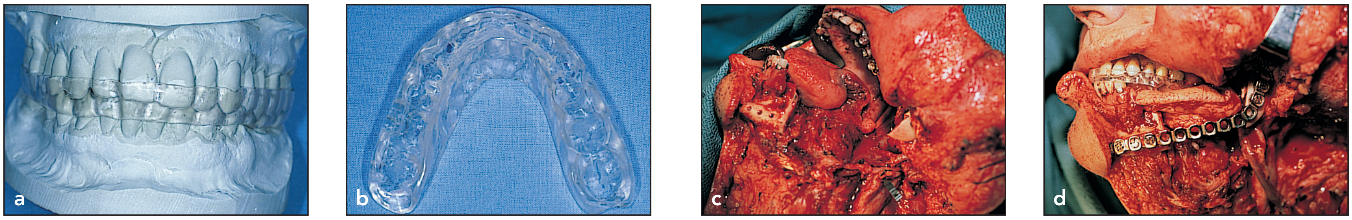

Fig 2-51 Use of surgical templates to properly position residual fragments and correctly align the graft segment. *(a and b)* Surgical template. Note the maxillary and mandibular occlusal indices. *(c)* Lateral composite resection defect. Prior to resection, the template is positioned and the mandible is placed in centric occlusion. A titanium-coated hollow screw and reconstruction plate (THORP) is adapted, and screw holes are placed. *(d)* THORP secured. A free flap has been inset. Note the presence of the template. Preoperative maxillomandibular relationships have been maintained.

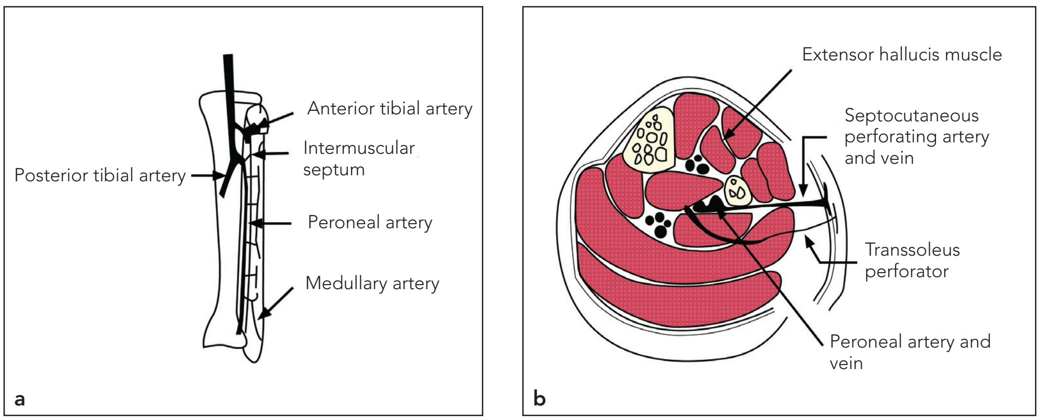

Fig 2-52 Blood supply for the composite fibular flap. *(a)* The principal blood supply to the fibula is the peroneal artery. Segmental periosteal vessels circle the fibula along its length. *(b)* Vasculature of the lateral leg. Note the perforating septocutaneous vessels. A skin island is centered over these vessels. (Adapted from Swartz and Janis[234] with permission.)

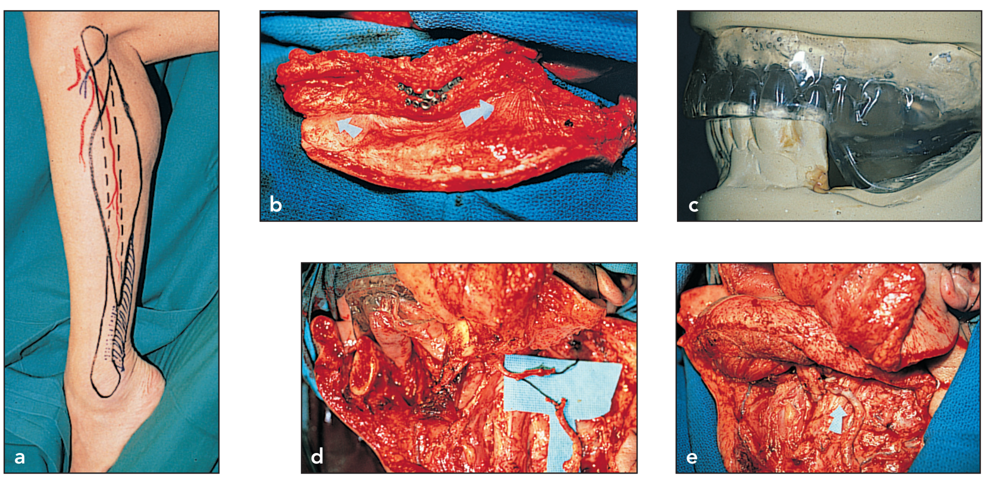

Fig 2-53 Composite fibular flap. *(a)* Outline of a fibula osteomyocutaneous free flap. Note the skin island and the course of the peroneal artery. *(b)* Flap perfused in situ. Osteotomies are performed in situ with the flap vascularized. Osteotomies are stabilized with miniplates and screws. The *arrows* point to vessel anastomosis. *(c)* Template prepared for use. *(d)* Composite anterior resection defect. Posterior mandibular fragments have been positioned in the template. *(e)* Fibular flap inset with the skin island rotated over the superior aspect of the bone component for intraoral closure. The flexor hallucis muscle has been used to replace resected submental musculature and separate the oral cavity from the neck, where microvascular anastomosis *(arrow)* has been performed.

some instances preoperative, contouring of the osseous portion of the free flap. A surgical stent is used to properly position residual mandibular fragments and correctly align the graft segment[233] (Fig 2-51).

Fibula. The composite fibular flap is nourished by the peroneal (fibular) vessels (Fig 2-52). The flap may be transferred with bone alone or with skin and muscle (Fig 2-53). The composite flap may include up to 25 cm of bone, more than 250 cm of lateral leg skin surface, a portion of the soleus muscle, and the entire flexor hallucis longus muscle if needed for complex defects.

The bone's length and extensive periosteal blood supply allows the reconstruction of the entire mandible.[235] Multiple osteotomies may be performed to replicate the contour of the resected mandible without risk of devascularizing the bone segments. At least 6 cm of bone is left proximally and distally to maintain respective joint stability. The fibula's cortical nature and thickness make it an excellent recipient of osseointegrated implants, and the success rates appear to be quite good.[226–238] Either leg may be utilized as a donor site, although the choice may be determined by the vascularity of the lower extremity, the side, location, and extent of the tumor resection, and the reconstructive surgeon's preference. When the ipsilateral neck is vessel depleted, the pedicle may be lengthened by using the distal bone and dissecting the periosteum.

The skin island is based on septocutaneous perforators, emanating through the posterior crural septum from the peroneal vasculature. The cutaneous portion of the flap may be used for intraoral, external, and combined defects. The flexor hallucis longus

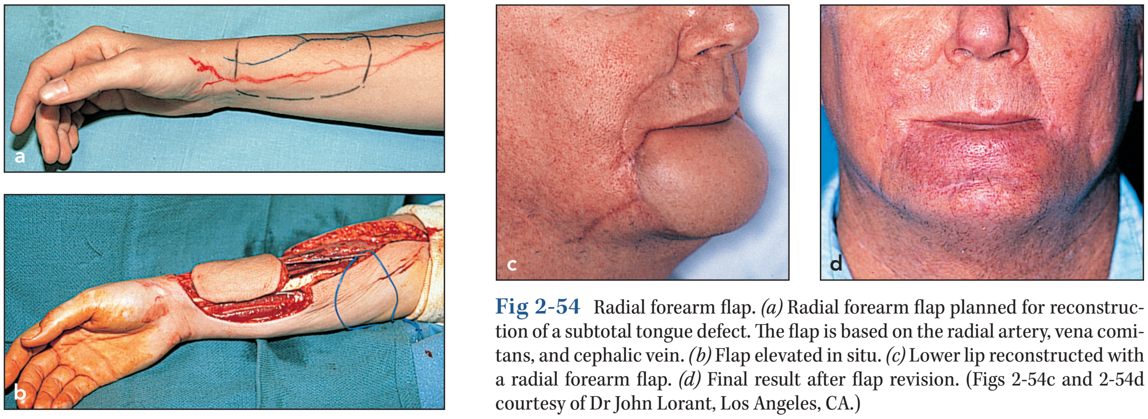

Fig 2-54 Radial forearm flap. *(a)* Radial forearm flap planned for reconstruction of a subtotal tongue defect. The flap is based on the radial artery, vena comitans, and cephalic vein. *(b)* Flap elevated in situ. *(c)* Lower lip reconstructed with a radial forearm flap. *(d)* Final result after flap revision. (Figs 2-54c and 2-54d courtesy of Dr John Lorant, Los Angeles, CA.)

muscle is routinely harvested with the flap. Its position along the inferior border of the bone make it an ideal substitute for the submental and submandibular soft tissues and it acts as an additional partition between the oral cavity and neck. Harvesting a 2-cm cuff of flexor hallucis and soleus also can enhance the vascular supply to the skin paddle by preserving musculocutaneous perforators traversing this location.

The composite fibular flap is the preferred donor site for most complex orofacial-mandibular defects. For defects of the lateral mandible that do not involve a significant amount of oral mucosa, the osseous flap may suffice, but the osteocutaneous flap is preferred. The addition of a skin island allows for absolute tension-free intraoral closure that enhances tongue mobility. It also permits monitoring of the otherwise buried flap more effectively. The donor site may be closed directly when less than 4 to 5 cm of skin are included with bone, but split-thickness skin grafting to the site must be considered in the majority of situations.

The fibula osteomyocutaneous flap is also recommended for lateral and symphyseal composite defects that include substantial amounts of intraoral mucosa, tongue, and external skin. As the mucosal defect enlarges, so do the harvested skin paddle requirements. Skin islands 10 to 12 cm wide are available for more extensive defects. A skin graft is necessary to close the donor site.

Radial forearm. The radial forearm fasciocutaneous flap is supplied by the radial artery, its venae comitantes, and superficial veins (Fig 2-54). The flap may be harvested with or without bone and may include both tendon and muscle. The composite flap may include 10 to 12 cm of bone, the entire skin of the volar and radial forearm, the palmaris longus tendon, and parts of the flexor radialis and flexor pollicis longus muscles. The medial and lateral cutaneous nerves may be included to make it a sensate flap.

Approximately one third of the circumference (radial aspect) of the radius is harvested as a monocortical graft. Several radial artery perforators traverse the flexor pollicis longus muscle in this region to supply the bone's periosteum. This maintains the viability of the bone graft, but a single osteotomy is all that is advised because of concerns about interrupting the blood supply. The bone can be folded on itself to increase its thickness, although its stock is not well suited for osseointegrated implants.

The skin island is centered between the radial artery and cephalic vein (when present) and includes volar ulnar extension when necessary. If the cephalic vein is not available, the flap is moved toward the ulna, and a superficial volar vein as well as the venae comitantes may be used for venous outflow. The cutaneous paddle is nourished by perforators traversing the lateral intermuscular septum. The fasciocutaneous component of the flap is thinner distally where the perforators are also more numerous.

The radial forearm skin island is an ideal substitute for intraoral lining and can also be used for external and combined defects (see Figs 2-28c, 2-40b, 2-46a, 2-46c, and 2-48). The nondominant upper extremity is the preferred site for flap harvest, although either side may be used because there is minimal long-term impact on function. A nondominant harvest site also allows better communication via writing for patients in the immediately postoperative period, when they are unable to speak because of the location of the surgery and the presence of a tracheotomy in many instances.

The fasciocutaneous soft tissue–only flap with a mandibular reconstruction plate is preferred for the reconstruction of composite posterolateral defects in patients with advanced disease and finite life expectancies or those edentulous patients whose anticipated masticatory forces are less than would warrant bone replacement (see Fig 2-42). The composite flap is used (more sparingly) for straight segmental bone defects that include buccal mucosa and/or floor of the mouth.[239]

The thinness of the tissue is this flap's major advantage and its disadvantage. It is an excellent substitute for intraoral lining but does not have sufficient volume for the more extensive composite resections. In addition, the bone is not of sufficient thickness for implants, long segment defects, or defects requiring multiple osteotomies.

Scapula. The composite scapular or parascapular flap is supplied by the circumflex scapular artery, through its terminal deep branches, the transverse and descending cutaneous branches, and venae comitantes (Fig 2-55). Approximately 12 to 14 cm of lateral scapular bone, 400 cm of the back skin, and the latissimus dorsi and serratus anterior muscles may be included in the flap for large and complex defects. The thoracodorsal vessels must be included when the latissimus or serratus muscle is used. The pedicle may be traced to the parent subscapular artery and vein for additional pedicle length and increased vessel caliber.

The lateral border of the scapula is dependent on the terminal intramuscular (deep) branch of the circumflex scapular artery for

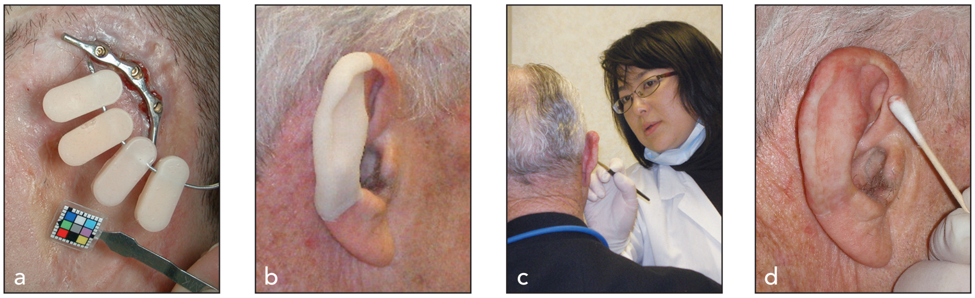

Fig 5-24 Color matching. *(a)* Shade guides will ensure consistency in the color and translucence of the base. *(b to d)* Coloration is accomplished under corrected light conditions.

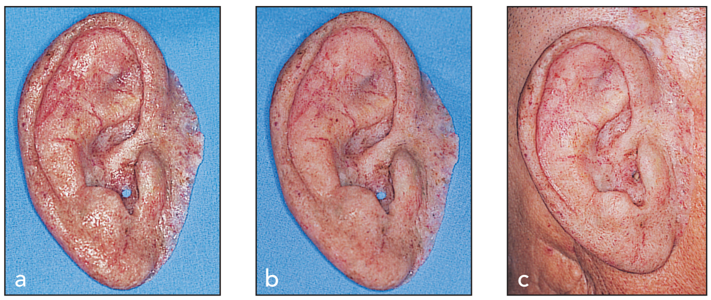

Fig 5-25 Elimination of shine after extrinsic coloration. *(a)* Before deglossing and after application of sealant. *(b)* After deglossing. *(c)* Prosthesis in position.

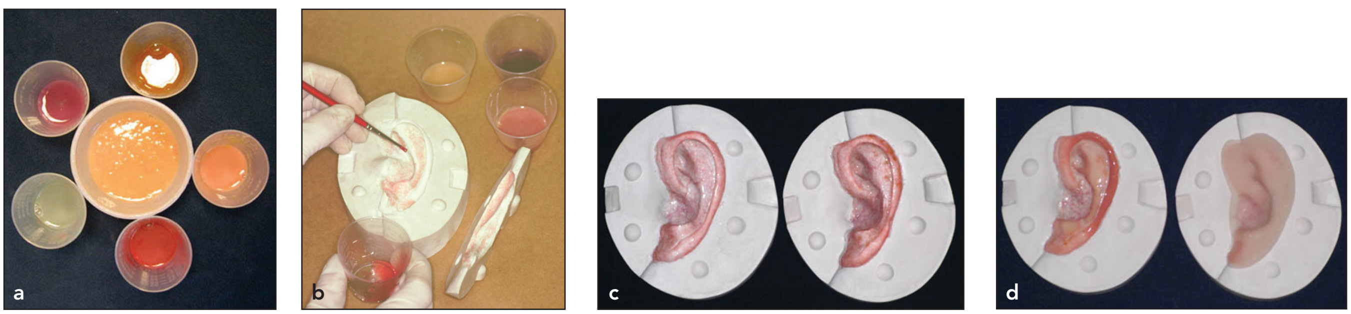

Fig 5-26 Color record for intrinsic coloration. *(a)* Catalyzed silicone colors. *(b)* Painting of initial color in mold. *(c)* Subsequent color layers in mold. *(d)* Base shade added to mold.

layer is allowed to partially catalyze before the subsequent one is placed. Then the base shade is placed, and the mold is closed and processed. A record of color samples and locations is kept for later prosthesis remakes (Fig 5-26).

Rehabilitation of Auricular Defects

Auricular defects occur secondary to congenital malformations, trauma, or surgical removal of neoplasms. Defects secondary to total resection of the auricle are easily rehabilitated prosthetically. Defects secondary to partial resection of the auricle or secondary to microtia are more difficult to rehabilitate.

Preoperative consultations are extremely valuable for patients with auricular tumors requiring resection. Besides informing the patient of the nature of the defect and the future prosthesis, preoperative impressions and photographs make construction of the postsurgical auricular prosthesis simple. After surgery, the wax duplicate of the patient's ear is easily positioned and adapted to the defect. All that remain to be completed are the placement and feathering of margins and the incorporation of appropriate surface detail.

Temporary auricular prostheses

In most patients, the tissue bed is sufficiently organized 4 to 6 weeks after surgery to allow placement of a temporary ear prosthesis. Use of heat-polymerizing acrylic resin to fabricate this temporary prosthesis will allow periodic adjustment and relining with a temporary denture reliner. Alternatively, a preoperative cast of the missing ear may be used to make a temporary prosthesis from silicone elastomer. This too may be refitted with silicone rubber as healing progresses.

Early rehabilitation of the defect is appreciated by some patients, and few complications have resulted from this practice. Retention is accomplished with medical grade skin adhesives. For most patients, 4 to 5 months is a suitable period to allow for organization and contracture of the wound before fabrication of the permanent prosthesis commences.

Definitive auricular prostheses

Impressions

Unlike orbital or nasal defects, the tissues in the auricular area are not displaceable, and significant distortions do not result from

Box 5-7	Recipe for custom sculpting wax
Ingredients	

- 1 lb beeswax (Factor II)
- Seven sticks of paraffin (canning supplies from grocery store)
- One or two sheets of pink baseplate wax (dental supply)
- Assorted crayons for custom color formula

Mixing instructions

- Melt beeswax, paraffin, and baseplate wax in a double boiler.
- After waxes have melted, remove a small quantity and add melted crayons to develop a custom color.
- Keep the individual wax formulas in an egg poacher (found at hardware stores).
- Evaluate by cooling several drops in cold water.

Fig 5-27 Dividing the normal ear into equal compartments will aid in sculpting. Note how the anterior margin is feathered.

postural changes. Consequently, the impression can be obtained with the patient positioned upright. lying on his or her side, or in a supine position. However, condylar movements should be closely examined, for they may result in tissue bed mobility, which can affect marginal placement, tissue coverage, and ultimately the retention of the prosthesis. The working cast may have to be lightly sanded in areas of functional soft tissue mobility to prevent gapping and allow a more intimate prosthesis fit in the condylar area.

Before the impression is made, a skin-marking pen may be used to place orientation marks such as the location of the external auditory meatus and the angulation of the long axis of the ear. The defect area is isolated with drapes, cotton is placed in the ear canal, and a suitable impression material is applied. Adjacent hair should be taped or covered with a water-soluble lubricant or cold cream. Petroleum-based products may interfere with processing of some silicones.

Disposable syringes are useful for depositing impression material into areas with difficult access. Light-bodied polysulfide, polyvinyl siloxane, and irreversible hydrocolloid are appropriate impression materials. If irreversible hydrocolloid is used, the addition of 50% more water will improve its flow properties and facilitate the impression procedure.

A backing of quick-setting plaster will provide suitable support for the impression. The plaster backing must be applied in succeeding thin layers to avoid distorting the underlying tissues and the impression. Strips of gauze or wisps of cotton partially embedded within the setting impression material and painted with the appropriate adhesive are used to unite the impression material with the plaster backing.

Sculpting

If a presurgical cast of the resected ear is available, it is reproduced in wax and compared to the remaining ear (Box 5-7). Use of a skin-colored wax rather than pink denture baseplate wax may be helpful because it gives the patient and clinician a more realistic idea of the definitive prosthesis. Appropriate changes are made in the basic contours, and at the next appointment the wax ear is positioned and adapted to the defect to achieve natural symmetry in all planes with the opposite side. A water bath and flame are necessary to complete this procedure successfully. A modified facebow or a Fox occlusal plane (Dentsply Trubite) may be useful aids to verify the position of the wax prosthesis.

If preoperative casts are not available, the prosthesis can either be sculpted from the beginning or the "donor" technique may be employed. In recent times, computer-aided design and computer-aided manufacture (CAD/CAM) techniques have become increasingly popular (see the discussion on page 299 as well as chapter 7). Sculpting an ear from the beginning is time consuming, but it may be necessary for selected patients. This task is facilitated by dividing the cast of the normal ear into equal sections so that contours are more easily verified (Fig 5-27).

The donor technique is an easier method. A person with ear contours that closely mimic those of the patient is selected. Often, this may be a family member. An impression of the appropriate ear of the donor is made and a wax cast is retrieved. The wax ear is adapted and recontoured as necessary. If the clinician makes wax duplicates of the ears of all auriculectomy patients, he or she soon will have a suitable donor supply and will not need to seek a donor.

When the position and basic contours of the wax pattern are acceptable, the patient is dismissed and the surface details are applied. The upper portion of the anterior margin will be exposed and should be carefully blended and feathered (see Fig 5-27). The middle portion should be wrapped around the tragus, if this structure is present. The inferior margin, in most patients (particularly elderly patients), should be made to look like a crease in the skin. The entire surface must be textured to match the skin textures of the adjacent skin and opposite ear. The texture should be made a little more prominent, because some detail is lost during processing and painting.

Proper texture is important for a number of reasons. First, without texture, the prosthesis can never be suitably matched to adjacent skin. Second, without texture, extrinsic tinting becomes extremely difficult inasmuch as appropriate application, control, and distribution of paint on a smooth surface is almost impossible. Care should be taken to avoid making the stipples excessively deep, because paint has a tendency to pool in deep stipples. Third, texturing provides mechanical retention for extrinsic colorants and lengthens the period of service of the prosthesis.

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